

A NEW GENUS OF BRISSID ECHINOID FROM THE UPPER OLIGOCENE OF VICTORIA

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A new genus and species of brissid heart urchin, *Apoxyptatum chenjafra* sp. nov., is described from the Late Oligocene Waurm Ponds Limestone at Waurm Ponds, Victoria. This small heart urchin is particularly characterised by the reduction in size of the ambulacral plates in the vicinity of the apical system. The echinoid fauna of the predominantly Late Oligocene Jan Juc Formation, within which the Waurm Ponds and Point Addis Limestones occur, is documented. The Waurm Ponds Limestone is shown to contain a spatangoid biofacies, the Point Addis Limestone a cassiduloid/clypeasteroid biofacies, and the rest of the Jan Juc Formation mixed spatangoid and clypeasteroid biofacies. Biofacies differences are considered to be due to variations between the units in sediment grain size, reflecting, in part, differences in depths of deposition.

THE WAURN PONDS Limestone is a 10 m thick sequence of predominantly bryozoal calcarenites that outcrops in a series of quarries along monoclinical structures at Waurm Ponds, west of Geelong in Victoria. This limestone occurs in the easternmost part of the Torquay Basin and is a member of the Jan Juc Formation, a predominantly Late Oligocene unit (Janjukian Stage, planktic foraminiferal zone 22) though the uppermost part is of earliest Miocene age (Abele 1976). The Jan Juc Formation is predominantly a glauconitic marl interbedded with sandy glauconitic calcarenite. Locally, bryozoal calcarenite-rich units are present, such as the Waurm Ponds Limestone and the Point Addis Limestone.

Fossil echinoids have long been known from the bryozoal calcarenites of the Waurm Ponds Limestone, McCoy (1882) having described *Pericosmus nelsoni* from a nodular limestone band near the base of the limestone. This species has more recently been placed into a separate genus named *Waurmia* by McNamara & Philip (1984). Intensive collecting at Waurm Ponds in the last few years, mainly by Chris Ah Yee and Janice Krause but also by Frank and Enid Holmes, has yielded a relatively diverse and distinctive echinoid fauna dominated by spatangoids. These collections have been made principally from the "Old Pit", to the west of the current quarry area (Fig. 1). This pit is the original pit of modern day workings and is distinct from the nineteenth century quarries from which McCoy (1882) obtained his material. On

the basis of some of the material collected by Chris Ah Yee, McNamara et al. (1986) redescribed *Granobrissoides australiae* (Cotteau). Other echinoids recently described or newly recorded from the Waurm Ponds Limestone are *Eupatagus collabus* Kruse & Philip, 1985, *Protenaster philipi* McNamara, 1985 and *Meoma tuberculata* Hutton (McNamara et al. 1986). The last species was previously known only from Early Oligocene strata in South Australia.

Recent collecting has focused on the basal part of the Waurm Ponds Limestone in the "Old Pit". The echinoids that have been discovered reinforce the rather unusual nature of the echinoid fauna by revealing another undescribed genus. Two of the other genera, *Waurmia* and *Granobrissoides*, are restricted to this unit. Unlike the coarse bryozoal nature of most of the Waurm Ponds Limestone, the basal part is a thin (less than 1 m), fine-grained calcarenite that also contains a lithic and glauconitic fraction. It occurs about 1.2 m below the bed within which *Waurmia nelsoni* has been found (McCoy 1882, Gill 1952). In addition to the new genus, which is represented by some 38 individuals, rare specimens of *Hemiaster verecundus* McNamara, 1987 and *Brissopsis* sp. have also been found in the basal bed (Chris Ah Yee, pers. comm.). This brings to 15 the number of echinoid species collected from the Waurm Ponds Limestone (Table 1, Fig. 5), though some of these species have not previously been recorded from the unit.

The material on which this study is based is

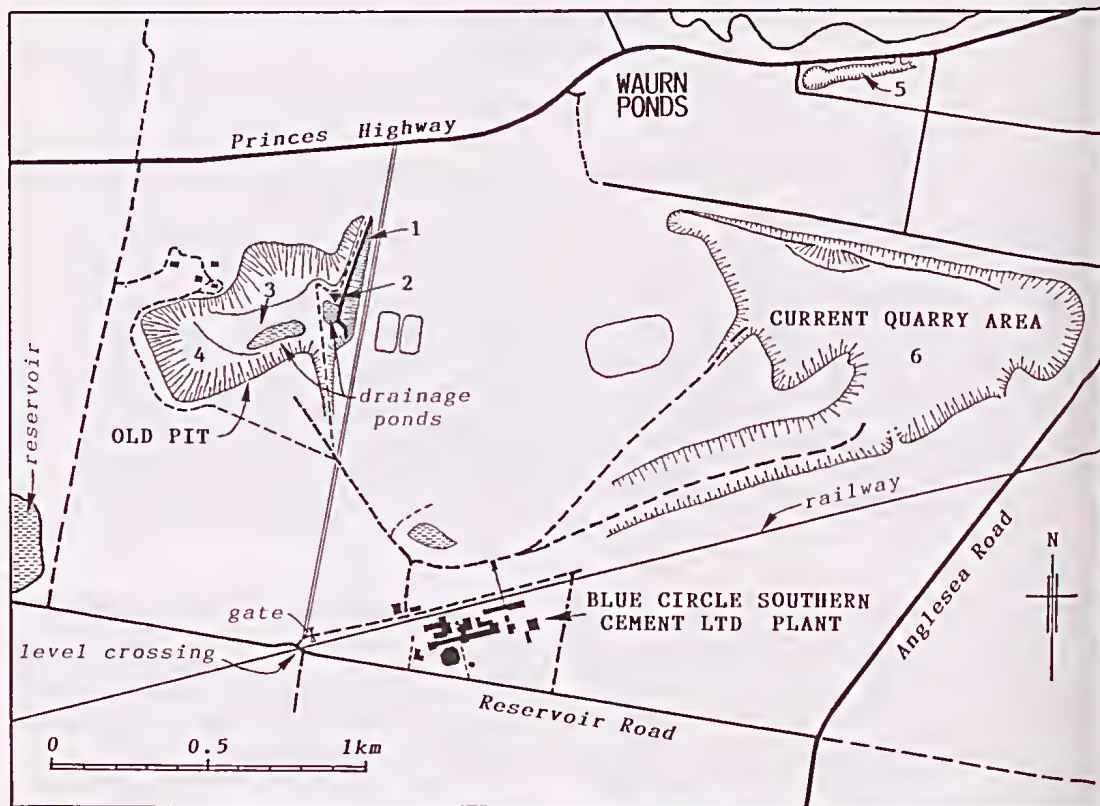


Fig. 1. Map showing location of quarries in the Waurn Ponds Limestone from which *Apoxyptalum chenjafra* and other echinoids have been collected. Map drawn by Mr Frank Holmes and based on January 1990 aerial photograph (Division of Survey and Mapping, Department of Property and Services, Victoria). 1, vertical cut along line of monocline (*Waurmia nelsoni* bed bottom 1 m of cut). 2, section of basal bed of quarry, immediately east of vertical cut, from which majority of specimens of *Apoxyptalum chenjafra* were collected. 3, base of quarry, sloping south to drainage pond, containing occasional echinoids including *Apoxyptalum chenjafra*. 4, area of quarry yielding most echinoids, in particular *Corystus dysasteroides*, immediately above an ironstone band about a quarter of the way up the slope. 5, old lime quarry and kiln, probably the quarry referred to by McCoy (1882) as the type locality of *Waurmia nelsoni*. 6, currently worked pit.

housed in the collections of the Western Australian Museum, Perth (WAM) and the Museum of Victoria, Melbourne (NMV).

SYSTEMATIC PALAEOONTOLOGY

Order SPATANGOIDA Claus, 1876
Family BRISSIDAE Gray, 1855

Genus *Apoxyptalum* gen. nov.

Etymology. From the Greek *apoxys* and *petalon*, referring to the reduced nature of the anterior petals. Gender neuter.

Type species. *Apoxyptalum chenjafra* sp. nov.

Diagnosis. Test cordate, with shallow anterior notch. Apex mid-test length, posterior to apical system which is about one-third test length from anterior. Ethmolytic, with 4 gonopores. Petals short and sunken adambitally but flush with test surface adapically; anterior petals almost transverse. Anterior poriferous row of anterior petals (IIb and IVa) with a greater number of smaller plates and more reduced pore pairs than posterior row. In both rows pore pairs fail to reach apical system, occurring only on distal parts of petals. In posterior petals inner and outer rows with equal number of reduced plates and pore pairs. Peripetalous fasciole very narrow; subanal fasciole very wide. Peristome subcentral.

Echinoid species	Waurn Ponds Lst.	Point Addis Lst.	Jan Juc Fm.
<i>Goniosigma murrayensis</i>	—	1	—
<i>Ortholophus woodsi</i>	—	4	2
<i>Zenocentrotus peregrinus</i>	—	1 ¹	—
<i>Corystus dysasteroides</i>	5	1	2
<i>Echinolampas curtata</i>	10	—	—
<i>Australanthus florescens</i>	6	36	—
<i>Apatopygus</i> sp.	—	1	—
<i>Fibularia gregata</i>	—	1	15
<i>Wiltingaster scutellaris</i>	10	23	25
<i>Monostychia</i> sp.	1	6	1
<i>Hemiasaster verecundus</i>	2	—	—
<i>Protenaster philipi</i>	5	—	—
<i>Waurnia nelsoni</i>	15	—	—
<i>Eupatagus wrighti</i>	—	3	40
<i>Eupatagus collabus</i>	2	—	—
<i>Brissopsis</i> sp.	0.5	1	1
<i>Grauobrissoides australiae</i>	6	—	—
<i>Lovenia forbesii</i>	2	22	15
<i>Meoma tuberculata</i>	0.5	—	—
<i>Pericosmus maceoyi</i>	0.5	—	—
<i>Apoxyptalum chenjafra</i>	34	—	—
	n = 196 ²	n = 105 ²	n = 83 ³

Table 1. Echinoid species found in the Late Oligocene strata of the Torquay Basin. Data presented as percentages of the total numbers of specimens found in each formation, based on collections held in the Western Australian Museum. ¹Only the holotype, described by Philip (1965), is known. ²Based on specimens collected by C. Ah Yee and K. J. McNamara. ³Based on specimens collected by K. J. McNamara.

Plastron with prominent keel, particularly posteriorly.

Remarks. Of brissids with an anteriorly positioned apical system and transverse anterior petals, *Apoxyptalum* bears a superficial similarity to *Brissus* but can be distinguished from that genus by its small size, the presence of an anterior notch, the shorter petals, the anterior petals that are only poriferous distally, the peripetalous fasciole that is not indented between the petals, the flatter adoral surface and the sub-central peristome. *Anabrissus*, which closely resembles *Brissus*, has a weak peripetalous fasciole like *Apoxyptalum* but has only three gonopores. *Apoxyptalum* is similar to the small, late Cretaceous to early Palaeocene *Diplodetus* (*Proto-brissus*); however, *Apoxyptalum* can be distinguished by its well developed subanal fasciole, more strongly vaulted test and incompletely poriferous petals (see Mortensen 1951, fig. 176).

Apoxyptalum is not unlike *Migliorinia*, from the Eocene of Somalia, but *Apoxyptalum* has shorter, much narrower petals and a more vaulted test, and in *Migliorinia* the pore pairs are not reduced adapically. The only brissid that

has reduced pore pairs near the apical system is *Brissopsis*, but that genus has reduced pores only in the anterior row of the anterior petals (ambulaera IIb and IVa) and in the posterior row of the posterior petals (ambulaera Ia and Vb); furthermore, it lacks the anteriorly positioned apical system and consequent transversely orientated anterior petals. Some species of *Macropneustes*, such as *M. minor* (Agassiz) from the Eocene of France, bear a superficial similarity to *Apoxyptalum*, but the new genus can be distinguished not only on the nature of the pore pair size in the petals but also in its much shorter petals and the absence of any large tubercles on the aboral surface of the test.

Amongst Australian spatangoids, *Apoxyptalum* is similar to the Miocene marsupiate genus *Peraspatangus*. Both genera share an anteriorly positioned apical system, transverse petals that adapically have reduced pore pairs, a keeled plastron and relatively posteriorly positioned peristome. However, *Peraspatangus* lacks a peripetalous fasciole and consequently was placed in the Spatangidae by Philip & Foster (1971). *Apoxyptalum* can further be distinguished by its anterior notch, sunken petals and absence of a marsupium in the females. *Apoxyptalum* is also

superficially similar to the Australian spatangoid *Spatagobrissus* (see McNamara et al. 1986) but can be distinguished by its smaller aboral tuberculation, sunken petals, anterior notch, larger peristome and flatter adoral surface.

Apoxypetalum chenjafra sp. nov.

Figs 2–4

Holotype. NMV P135991 (Fig. 2A–D), from the Janjukian (Late Oligocene) Waurn Ponds Limestone, Blue Circle Southern Cement Quarry, Reservoir Road, Waurn Ponds, Victoria (Geelong 1:25,000 topographic map 7721-1-3, grid reference BT 603666). The quarry is situated between the Princes Highway and Reservoir Road, 1 km north-west of BCSC buildings. The specimen was collected from the basal bed of the Waurn Ponds Limestone at the north-eastern end of the quarry (see Fig. 1).

Other material. Paratypes NMV P135989, P135990, P135992, P135993 and WAM 92.374–382 from the same horizon and locality as the holotype. A further 24 incomplete specimens were also collected: WAM 90.266–268, 90.269 (7 specimens), 91.8, 91.11, 92.383 (12 specimens).

Etymology. An arbitrary combination of letters taken from the first names of the four collectors of the specimens, respectively Chris Ah Yee, Enid Holmes, Janice Krause and Frank Holmes. Consequently the species name is pronounced "ken-ja-fra". The name should be considered as a noun in apposition.

Diagnosis. As for genus.

Description. Test small, reaching a maximum known test length (TL) of 23.5 mm; cordate, with shallow anterior notch; highest in interambulaerum 5 (Fig. 3D), near mid-test length (between 47% TL and 56% TL from anterior ambitus), height 54–62% TL; test widest just anterior to mid-test length but posterior to apical system, maximum width 90–98% TL. Aboral surface strongly convex, declining steeply anteriorly; posteriorly truncated, interambulaerum 5 slightly overhanging periproct. Apical system anterior to centre, 35–41% TL from anterior ambitus; ethmolytic, with four genital pores.

Ambulaerum III shallow on aboral surface; narrow adapically, progressively broadening adambitally; with up to 12 very small pore pairs; pore pairs aligned obliquely almost exsagittally;

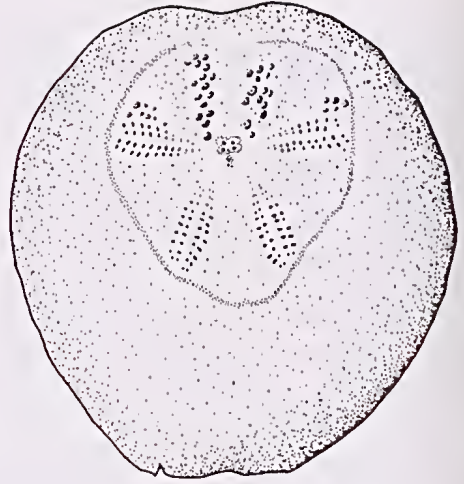
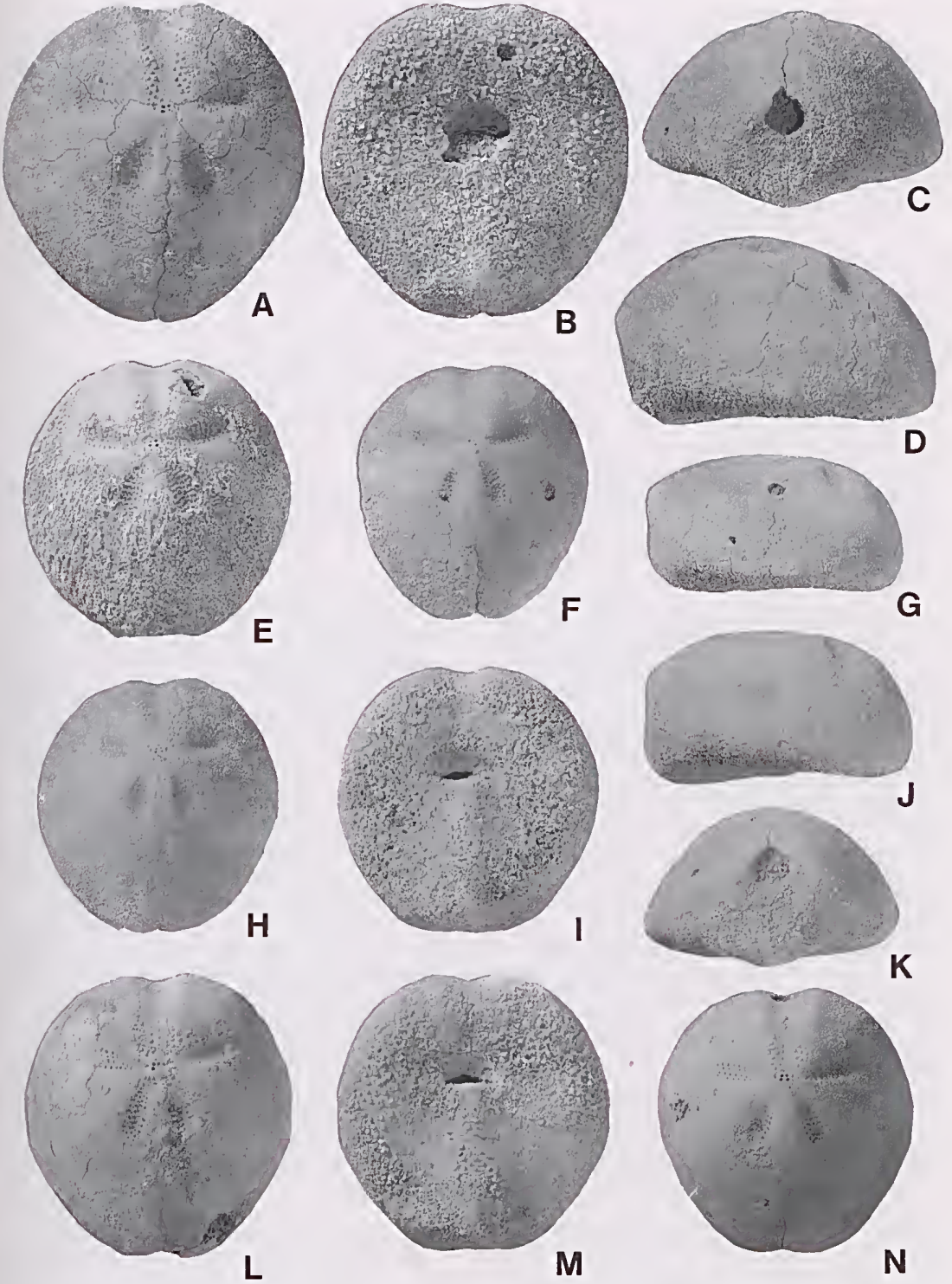


Fig. 2. Camera lucida drawing of aboral view of *Apoxypetalum chenjafra*, WAM 91.9. Bar represents 5 mm.

not conjugate. Anterior petals shallow; narrow, width 7–8% TL; almost transverse, diverging anteriorly at about 160°; short, 22–27% TL; pores circular to ovoid, not conjugate; 12–14 pore pairs in anterior row (ambulaera IIb and IVa); 11–15 in posterior row (ambulaera IIa and IVb); in anterior row, abapical 5–7 pore pairs large, adapical 5–7 pore pairs very reduced in size; in posterior row larger pore pairs are more numerous, abapical 8–10 being large whereas adapically only 3–5 are reduced in size. Pore pairs fail to reach apical system (Figs 2, 3N, 4). Posterior petals shallow and same width as anterior petals; usually same length as anterior petals but in two individuals they are shorter (22% TL compared with 26% TL); total variation in length is 21–27% TL; 11–15 pore pairs in each row, fewer in smaller than in larger specimens; unlike anterior petals, rows bear roughly equal number of pore pairs, 7–10 large pore pairs and 4–6 small ones. Both anterior and posterior petals are only sunken in region containing larger plates pierced by larger pore pairs; adapical parts of petals with smaller plates and small or absent pores not sunken. Peripetalous fasciole very narrow (Fig. 2); only slightly indented between petal extremi-

Fig. 3. *Apoxypetalum chenjafra* gen. et sp. nov. A–D, holotype, NMV P135991, aboral, adoral, posterior and lateral views. E, paratype, WAM 92.375, aboral view of specimen with spines. F, G, paratype, WAM 92.377, aboral and lateral views. H, paratype, WAM 91.9, aboral view. I–K, N, paratype, WAM 92.374, adoral, lateral, posterior and aboral views. L, M, paratype, NMV P135989, aboral and adoral views. All specimens from the Waurn Ponds Limestone, Waurn Ponds, Victoria. All $\times 2$.



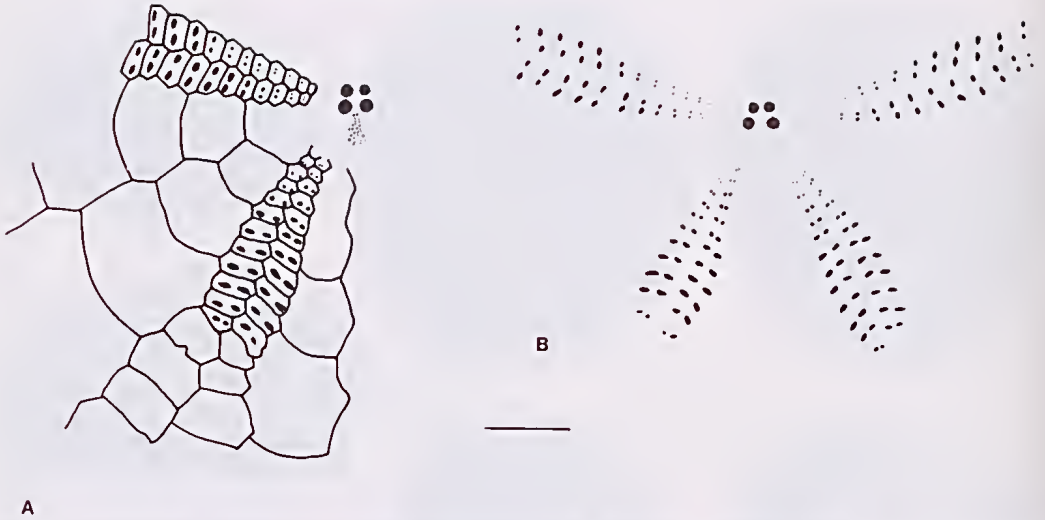


Fig. 4. Camera lucida drawings of part of the aboral surface of *Apoxyxypetalum chenjafra*. A, NMV P135989, part of aboral plating, apical system and pore pairs. B, WAM 92.374, genital pores and pore pairs, illustrating how the pore pairs fail to reach the apical system, and the reduction in pore pair size in the anterior row of the anterior petals. Bar represents 2 mm.

ties; crossing ambulacrum III close to apical system where anterior face of test plunges steeply to ambitus. Aboral tubereulation sparse, tubereles generally small, with diameter of about 0.15 mm; however, tubereles larger near petals and on flanks of ambulacrum III (Figs 2, 3A, H, L, N), with diameter of 0.4 mm. In one specimen (WAM 92.375, Fig. 3E) some of the aboral spines are preserved. These are straight to slightly curved, never more than 2 mm long, and 0.1 mm wide.

Peristome relatively large (Fig. 3B, I, M), width 18–22% TL in adults; not sunken, situated subcentrally with anterior of labrum 40–43% TL from anterior ambitus; few specimens have well preserved adoral surfaces, nature of phyllodal pores thus unknown. Labrum short, about as long as wide; only slightly convex anteriorly. Plastron relatively narrow, gradually increasing in width posteriorly to width of 25% TL; with a sharp sagittal keel (Fig. 3C, K) which increases in intensity posteriorly. Periproct circular (Fig. 3K), with diameter of 12–14% TL. Adoral tubereulation sparse; tubereles relatively large, up to 0.7 mm in diameter, and erenulate.

Discussion. *Apoxyxypetalum chenjafra* can be distinguished from the other two, small echinoids that coexist with it in the basal part of the Waurn Ponds Limestone, namely *Hemiaster verecundus* McNamara, 1987 and *Brissopsis* sp., largely

on the basis of its transverse anterior petals and anteriorly positioned apical system. It can further be distinguished from *H. verecundus* by its cordate test which is not so strongly vaulted posteriorly and by its narrower petals. It also differs from *Brissopsis* sp. in lacking adapically coalesced petals and in having a more vaulted test.

A number of specimens show evidence of having suffered predation, probably from cassid gastropods. McNamara (1990) reported the common occurrence of such predation in some Miocene spatangoids. Of specimens of *Apoxyxypetalum chenjafra* that are more than 75% complete, 38% ($n = 16$) show evidence of probably lethal predation in the form of a circular perforation in the test. These perforations, which range in diameter between 0.9 and 1.8 mm (mean = 1.3 mm), are located on the aboral surface in 66% of specimens (Fig. 3F, G), on the anterior ambitus (Fig. 3N) in 17% and on the adoral surface (Fig. 3B) in another 17%. This is the stratigraphically oldest reported evidence for gastropod predation on Australian echinoids.

LATE OLIGOCENE ECHINOID BIOFACIES OF THE TORQUAY BASIN

The Late Oligocene strata of the Torquay Basin outcrop predominantly in coastal cliff sections

in the vicinity of Torquay. The principal unit, the Jan Jue Formation, consists at its type locality at Bird Roek near Torquay of 9.8 m of olive grey and brownish grey silty, glauconitic marl, interbedded with clayey sandy glauconitic calcarenite (Abele 1976). In subsurface the unit reaches up to 88 m in thickness. The echinoid fauna discussed in this study was collected by the author at Fisherman's Steps and is represented by eight species (Table 1). It is dominated by spatangoids and clypeasteroids, which together comprise 76% of the echinoid fauna and 97% of the specimens collected (Table 2). More than half (65%) of the fauna comprises individuals of two species: the spatangoid *Enpatagus wrighti* and the clypeasteroid *Willungaster scutellaris*. Two further species, *Fibularia gregata* and *Lovenia forbesii*, make up a further 30%. Thus 95% of individuals of this echinoid fauna comprise just half of the total known species.

At Point Addis the Jan Jue Formation is represented by the Point Addis Limestone, a sandy bryozoal calcarenite more than 12 m thick (Abele 1976). The echinoid fauna is more diverse than that of the Jan Jue Formation (*sensu stricto*), being represented by 12 species (Table 1). The dominant group, comprising 37% of the fauna, is the cassiduloids, a group unknown in the Jan Jue Formation. Clypeasteroids and spatangoids together make up more than half of the remaining echinoid orders—30% and 26% respectively (Table 2)—this being almost half of the complement of these groups in the Jan Jue Formation. The dominant species in the Point Addis Limestone is the cassiduloid *Anstralanthus florescens*, individuals of which represent a third of the echinoid fauna. Apart from *Willungaster scutellaris* and *Lovenia forbesii*, the rest of the echinoids are rare elements of the fauna (Table 1). Thus a quarter of the echinoid species from the Point Addis Limestone are represented by 81% of the specimens collected. Of the total of 21 echinoid species known from the Upper Oligocene in the Torquay Basin, eight are shared by

the Jan Jue Formation and the Point Addis Limestone. Of these, only two species occur with some degree of frequency in both units: *Willungaster scutellaris* and *Lovenia forbesii* (Table 1). The most common species in the Point Addis Limestone, *Anstralanthus florescens*, is not known from the Jan Jue Formation, while *Eupatagus wrighti*, the dominant member of the Jan Jue Formation, is a rare element in the Point Addis Limestone.

The echinoid fauna of the Waurm Ponds Limestone (Fig. 5) is even more distinct from that of the Jan Jue Formation and the Point Addis Limestone than the echinoid faunas of these units are from each other. Of the 21 Late Oligocene species known from these three units only five are shared by the Waurm Ponds Limestone and the Point Addis Limestone, and only four with the Jan Jue Formation. Indeed, only four species occur in all three formations: *Corystus dysasteroides*, *Willungaster scutellaris*, *Brisopsis* sp. and *Lovenia forbesii*.

A distinctive feature of the Waurm Ponds echinoid fauna is the dominance of spatangoids, which comprise almost three-quarters of the echinoid fauna, both in terms of number of species and numbers of individuals (Table 2). In this respect the fauna is quite different from that of the Point Addis Limestone, which is dominated by cassiduloids and clypeasteroids. This is so even though both faunas inhabited similar sediments of relatively coarse bryozoal calcarenites. The Jan Jue Formation is somewhat intermediate in character, being a mixed spatangoid/clypeasteroid fauna. Another characteristic feature of the Waurm Ponds Limestone echinoid fauna is the high percentage of endemic genera, higher than for any other southern Australian Tertiary formation, the genera *Waurmia*, *Granobrissoides* and *Apoxyptelium* being known only from the Waurm Ponds Limestone.

Within the Waurm Ponds Limestone there are minor differences between the lower and upper beds. The lower beds (0–2 m) are dominated by

Echinoid orders	Waurm Ponds Lst.	Point Addis Lst.	Jan Jue Fm.
Regulars	—	6 (25)	2 (12)
Holasteroids	5 (7)	1 (8)	1 (12)
Cassiduloids	16 (14)	37 (17)	—
Clypeasteroids	11 (7)	30 (25)	41 (38)
Spatangoids	68 (72)	26 (25)	56 (38)

Table 2. Distribution of echinoid orders in the Late Oligocene strata of the Torquay Basin. Data presented as percentages of the total numbers of specimens and species (italics) found in each formation, based on collections in the Western Australian Museum.

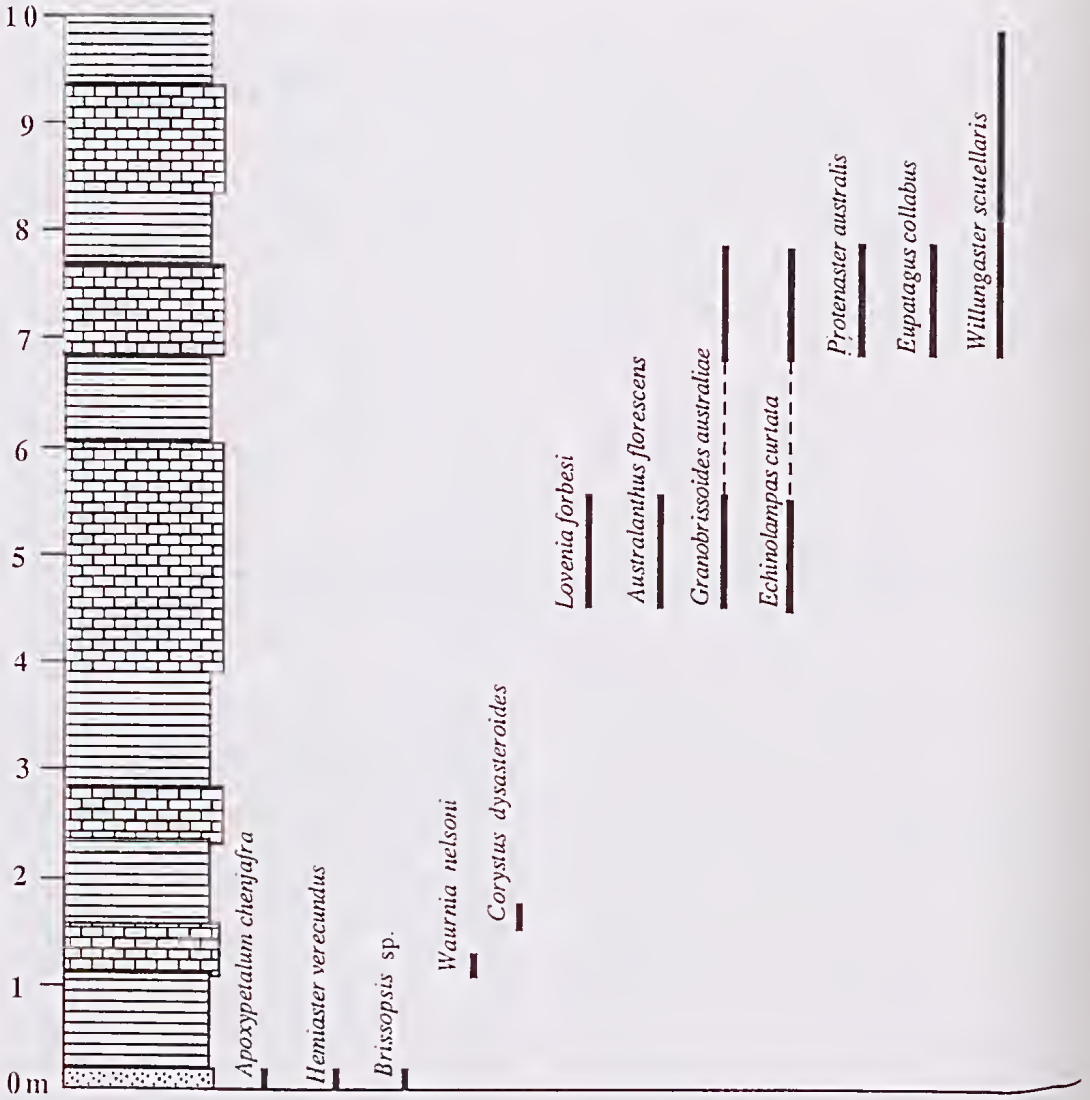


Fig. 5. Diagrammatic section through the Waurn Ponds Limestone in the "Old Pit", showing main fossiliferous horizons and distribution of echinoid taxa. Stippling represents basal sandy unit with *Apoxypetalum chenjafra*; horizontal parallel lines represent more marly horizons; brick pattern represents bryozoal calcarenite beds in which the echinoids occur. *Pericosmus maccoyi* and *Meoma tuberculata* are not included because their stratigraphic position in the section is not known.

spatangoids (four out of the five genera, the fifth being the holasteroid *Corystus*). *Apoxypetalum chenjafra*, which comprises 30% of the fauna, and *Waurnia nelsoni*, the next most common species in the Waurn Ponds Limestone (19%), are both found in the basal part of the Waurn Ponds section (Fig. 5). The upper beds (4–10 m) contain spatangoids, cassiduloids and a clypeas-

teroid. But even here spatangoids are dominant, comprising four of the seven genera.

Analysis of the echinoid faunas of southern Australia (McNamara in prep.) is revealing that distinctive echinoid biofacies can be recognised on the basis of the ordinal composition of the fauna. Regular and holasteroid echinoids usually comprise a very small component of the

echinoid faunas, which are dominated by spatangoids, cassiduloids and clypeasteroids. The irregular echinoids in particular are unlikely to have suffered much post-mortem transportation, as they are generally found complete, or nearly so. The delicate nature of the spatangoid test means that even minor post-mortem transportation would result in destruction of the test. Two basic biofacies can be recognised: a spatangoid biofacies, usually found in finer-grained sediments, and representing faunas that dwelt in relatively deep, quiet water (e.g. the echinoid fauna of the Rutledge Marl; see McNamara 1991); and a cassiduloid/clypeasteroid biofacies, generally found in coarser-grained calcarenites deposited in a higher hydrodynamic environment, and representing shallow water faunas. Cassiduloids dominated in the early Tertiary (e.g. the Late Eocene Tortachilla and Nanarup Limestone faunas of South and Western Australia respectively) but were partially replaced by clypeasteroids in later Tertiary faunas (e.g. some of the Miocene formations of the Murray Basin). Challis (1979) has recognised a range of generic echinoid biofacies in Miocene strata of the Maltese Islands. She has likewise noted that spatangoid-dominated biofacies correspond more with fine-grained sediments deposited in deeper water than do cassiduloid/clypeasteroid-dominated biofacies, which are characteristic of coarser-grained sediments deposited under shallower-water conditions.

Of the Late Oligocene echinoid faunas of the Torquay Basin, the Point Addis Limestone fauna can be placed within the cassiduloid/clypeasteroid biofacies, while the Waurm Ponds Limestone fauna is characterised as a spatangoid biofacies. Although both of these units are dominated by bryozoal calcarenites, the nature of the echinoid biofacies suggests that the Point Addis Limestone was deposited in shallow water whereas the Waurm Ponds Limestone was deposited under deeper-water conditions. This conclusion is supported by the rarity in the Waurm Ponds Limestone of regular echinoids, which are absent in other deep-water faunas such as those of the Rutledge Marl (McNamara 1991). Unlike the Point Addis Limestone, the Waurm Ponds Limestone bryozoal calcarenites are intercalated with marl and clay horizons. The intermediate nature of the echinoid biofacies of the Jan Juc Formation suggests that it may have been deposited under water depths intermediate between those under which the other two units were deposited.

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